PUBLICATION 365

1983-84
GREENHOUSE
VEGETABLE
PRODUCTION
RECOMMENDATIONS

Ministry of
Agriculture
and Food
ONTARIO
Dennis Timbrell
Minister

This publication is reviewed regularly by the Ontario Crop Protection Committee, the Ontario Greenhouse Vegetable Committee, and the Ontario Soil Management Research Committee. The recommendations may be revised whenever additional material is available.

Discard old editions of the Production Recommendations.

Amounts of material are for 1000 litres (L) of water unless otherwise stated.

ABBREVIATIONS

bu = bushel
°C = degrees Celsius
cm = centimetre(s)
D = dust
EC = emulsifiable concentrate
°F = degrees Fahrenheit
G = granules
gal = gallon(s)
in. = inch(es)
kg = kilogram(s)
L = litre
lb = pound(s)
M = metre(s)
m = square metre(s)
m = cubic metre(s)
mL = millilitre
ppm = parts per million
qt = quart(s)
SC = spray concentrate
SP = soluble powder
tbsp = tablespoon(s)
WP = wettable powder
yd = yard(s)
% = percent (by weight)

All pesticide products are registered by Agriculture Canada. No pesticide may be used on any crop for which it is not registered. Such use can result in seizure of the crop.

All information and recommendations contained in this publication relating to the use of pesticides have been reviewed by the Ontario Pesticides Advisory Committee.

CONTENTS

Abbreviations		Inside Front Cover
Cultivars	Cucumber	4
	Tomato	4
	Lettuce	6
	Radish	6
Soil Management	Soil testing	6
	Soil sterilization	8
	Pre-crop fertilizers	9
	Lime requirement table	10
	Soilless culture	10
	Soil mixes for seedlings	10
	Straw bale culture	11
Crop Management	Seed treatment	12
	Seedling production and timing	12
	Transplanting: spacing, temperature	13
	Fertilizer schedules	13
	Tissue testing	16
	Carbon dioxide enrichment	17
	Pollination: vibrating, bees	17
	Sanitation	18
Crop Protection	Monitoring insect outbreaks	19
	Application equipment	19
	Pesticides: applications and precautions	19
	Cucumber diseases	20
	Cucumber insects	24
	Tomato diseases	27
	Tomato insects	31
	Lettuce and radish diseases	33
	Lettuce and radish insects	33
Precautions with Pesticides	Pesticide poisoning	34
	Protective clothing	34
	Additional precautions	37
	Blood tests for those applying pesticides	38
	Relative toxicities of recommended pesticides	38
	If accidents occur	38
	Special instructions	39
	Methyl bromide and insecticide smokes	39
	Reentry to treated areas	40
	Pesticide storage	40
	Disposal of pesticide containers	40
	Common names of fungicides	41
	Common names of insecticides	41
Extension Horticulturists		42
Pesticide Control Field Offices		43
The Metric System		45

CULTIVARS

Cucumber

Two distinctly different types of cucumber are available for production in greenhouses: (1) the seedless; and (2) the seeded or "slicing" cucumber.

Seedless Cucumbers: These cultivars set fruit without pollination and are, therefore, seedless. Fruits are 30-45 cm in length, generally smooth, uniform green, and non-bitter.

Pollination of seedless cucumbers causes off-shape fruit and bees must be prevented from entering the greenhouse (see page 17). To help overcome this, gynoecious cultivars have been developed which bear almost 100% female flowers. Only gynoecious cultivars are now recommended for commercial production.

Recommended cultivars are:

(1) Sandra—consistently high yielding in trials. Good color, intermediate neck. Long fruit, 40 cm.

(2) Farbio—fruit has very good color and is slightly ribbed. Main stem fruit may be short if too many fruit are allowed to develop at the same time.

(3) Corona—dark colored, ribbed fruit. Fruit is larger than Farbio. Excellent shelf life.

Seeded Cucumbers

These are essentially regular slicing types, with fruits 18-25 cm. The flowers require pollination to ensure fruit set (see page 17), and thus the fruits contain well-developed seeds. They lend themselves well to "central-pack handling," and generally have a good shelf life.

Recommended cultivars are:

Burpee Hybrid—a vigorous hybrid and a good producer. Color and quality are good early in the season, but color is difficult to maintain late in the season.

High Mark II—retains color and quality throughout the season, does best under warm sunny conditions and long days.

Tomato

There are a number of cultivars of tomatoes recommended for production in Ontario greenhouses. To help you decide which one to plant, recommended cultivars are listed with some of the important characteristics of each.

Resistance code: Letters after the descriptions of each cultivar indicate their disease resistance as follows:

C_2 — leaf mold partial resistance
C_3 — leaf mold complete resistance
F_1 — fusarium wilt - race 1
F_2 — fusarium wilt - race 1 & 2
FCRR — fusarium crown and root rot
N — nematode resistance
Tm — tomato mosaic virus
V — verticillium resistance

Ohio CR-6—Pink—A fusarium crown and root rot resistant variety that should be grown where this disease has been a problem. Very vigorous plant growth. An excellent performer during spring and summer months but in early winter may be difficult to set and may produce rough fruit on the lower clusters. Generally takes 7-10 days longer to come into production than other cultivars. Tm, F_1, FCRR, V.

Ohio MR-13—Pink—Uniform ripening. Similar to WR-25, but not as subject to magnesium deficiency, slightly later in maturity. Subject to rough fruit unless adequate temperature is maintained. Not recommended for fall crop. Tm, F_1.

Ohio WR-25—Pink—Uniform ripening, produces medium to large fruit. It is a heavy feeder after fruit set is well under way and resists cracking. Relatively free from blotchy ripening but susceptible to magnesium deficiency, mosaic and leaf mold. Produces excellent yields both in spring and fall crops where these disorders can be kept under control. F_1.

Ohio Hybrid 7—Pink—Uniform ripening. Fruit size similar to MR-13, but slightly flatter. More vigorous plant type than MR-13. Should be watered and fertilized less than MR-13. Best suited for fall crop. Sets easily. Tm, F_1, V.

Ontario Pink 774—Pink—Fruits are a rich rose pink, smooth and of acceptable size. It grows well and sets easily at lower than normal temperatures. Susceptible to cracking, especially under fall conditions of cool nights and high humidity, which allows water to condense on the fruit. Tm, C_3.

Dombito—Red—A cultivar recently introduced from Holland. Produces excellent yields of large fruit under Ontario conditions. It is popular with many growers both for spring and fall crops. Vigorous plant growth and abundant foliage. Tm, C_2, F_2.

Jumbo—Red—Very similar to Dombito, plant growth possibly more dense. Has yielded well both for spring and fall crops; good fruit size and quality. No disease resistance.

Ontario Red 775—Red—Generally similar to Ontario Pink 774 in resistance, fruit quality and growth habit, but the fruit is red. Tm, C_3.

Laura (for trial)—Red—Previously tested experimentally as 79-W-77. The most productive cultivar in tests at H.R.I.O., Vineland for the past 3 years. A vigorous, compact plant with good fruit size. Tm, C_2, F_2, V.

Bruinsma 493 and 732 (for trial)—Red cultivars with multiple disease resistance and nematode resistance. Have performed well for fall crops in the Leamington area. Similar in growth habit and production to Jumbo and Dombito. Tm, C_2, V, F_1, N.

Lettuce

(1) *Looseleaf Type*

Grand Rapids Forcing—light green color, resistant to tip burn.

Waldmann's Dark Green—darker in color than Grand Rapids, large leaves.

(2) *Dutch Butterhead Type*

Deci-minor has performed well in trials in Ontario. This is a new type of lettuce for greenhouses and should be planted on a limited basis only until market outlets, etc. are thoroughly investigated.

Radish

Scarlet Globe-Forcing—short top, matures early.

Cherry Belle—smooth, uniform, good color.

GREENHOUSE SOIL MANAGEMENT

Soil Testing

Before planting greenhouse vegetable crops, it is advisable to have soil tested and nutrient levels properly adjusted. After planting, soil tests should be made at regular intervals. Soil analysis for greenhouse crops are made at the Department of Horticultural Science, Ontario Agricultural College, University of Guelph, Guelph, Ontario.

1. How should a soil sample be taken?

Because only a small amount of soil can be sent in for test, it is important that this amount truly represents the composition of all the soil in the area to be tested. To ensure this, take a number of samples in each house, or section of a house, and bulk them. Then mix these subsamples and take out the amount to be sent away. If the house is small and uniform, one composite sample should be enough. From a large house, several samples from different parts of the house should be sent. Approximately the same amount of soil should be included from all depths to 30 cm.

The final sample to be sent for analysis should weigh from 0.2 - 0.5 kg.

2. When should a soil test be made?

A soil sample should be taken and a soil test made in advance of planting a new crop. Soil samples should be taken two or three times during the growing season and the resulting nutrient levels should be considered in conjunction with the fertilizer schedules. In addition, a soil sample should be taken whenever a suspected fertility problem exists in a greenhouse. It usually takes about two weeks to get results back to the grower, so it is important to send samples in as quickly as possible after any disturbance or any abnormality is noticed.

3. How and where should a soil sample be sent?

The samples should be put into a clean, rigid container that can be sent safely through the mail. The Ministry of Agriculture and Food or the Department of Horticultural Science, University of Guelph, will send self-addressed containers on request. Packages must be clearly marked as greenhouse soil samples and addressed to: Department of Horticultural Science, Ontario Agricultural College, University of Guelph, Guelph, Ontario N1G 2W1. Mail first class to avoid delays.

To help the specialist making the fertilizer recommendations, the following minimum information should be sent with the samples:

(1) the crop that is to be grown, or is now growing;
(2) date of planting; and
(3) comments on the vigor of the present or past crop.

This information is essential to enable the Fruit and Vegetable Specialist to make reliable suggestions for fertilizer use.

Table 1. Explanation of soil test values

	Low	Normal	High	Danger**
	*ppm	ppm	ppm	ppm
Nitrogen (N)	0-5	6-35	36 +	
Phosphorus (P)	0-6	7-16	17 +	
Potassium (K)	0-29	30-60	61-79	80 and over
Calcium (Ca)		100 and over		
Magnesium (Mg)	0-19	20-30	31 +	
Sulfate (SO_4)		less than 300		300 and over
Chloride (CL)		less than 50		50 and above
pH		6.0-7.2		
Total Salts	0-29	30-79	80-99	100 and over

**Parts per million*

***These "danger" levels can be especially injurious to young seedlings. Leach to remove the excess.*

Soil Sterilization

To prevent severe losses due to nematodes and soil-borne diseases, it is necessary to destroy as many of the causal organisms as possible by steaming or fumigating the soil between crops. Steam, properly applied, kills all living organisms in the soil and is still the most effective means of sterilization However, it is sometimes unnecessary to steam between certain crops, and it may not be economically desirable. At such times fumigants can be suitable substitutes for steam. For further information, write for OMAF Factsheet *Sterilization of Greenhouse Vegetable Soils*, Agdex 290/516.

Soil Steaming

Where steam is used, maintain a temperature of not less than 80°C for 30 minutes throughout the soil, or in ground beds to a depth of 36 cm. Use an accurate thermometer. At higher temperatures, beneficial soil organisms start to be destroyed. Thus, if soil is overheated for too long, it becomes subject to a greater degree of re-infection because all the organisms have been destroyed. Other undesirable effects of oversteaming include: (a) excessive ammonia release; (b) manganese toxicity; (c) higher total salts levels; and (d) destruction of organic matter. Leaching is usually required after steaming. Do not use ammonium fertilizers for at least two months after steaming.

Soil Fumigation

Some fumigants control fungi, bacteria, nematodes, insects and weeds, whereas others which are more specific in their action control only nematodes or fungi. Soil fumigation is not always an adequate substitute for soil steaming. Fumigants do not destroy all soil-borne viruses harbored in root debris and other plant parts.

For fumigation of soil in bulk piles or stacked flats use cans of Methyl Bromide + Chloropicrin (MC-2 or MB-C_2) at 0.3 kg/kg/m^3. (See licensing requirements, page 40.)

Fumigants listed below are effective as preplanting treatments for greenhouse soil beds. Unless otherwise stated AMOUNTS ARE FOR 100 SQUARE METRES. Do NOT apply fumigants when the soil temperature is less than 13°C. Ensure that all traces of the fumigant have escaped from the soil before seeding or setting transplants. To check this, set a few plants in the soil a few days before planting would normally begin, and watch their reaction. Always follow manufacturer's directions very carefully.

(1) Control of Fungi, Nematodes, Insects and some Bacteria
Basamid (granular) 3.25-5 kg incorporated thoroughly and evenly in a warm soil to a depth of 15-23 cm. Consult label before use.
Mylone (granular) 8.5 kg
Vapam (liquid) 10 L

Vorlex (liquid) 6 L

Methyl Bromide + Chloropicrin

— pressurized cans containing 98% methyl bromide + 2% chloropicrin 7.5-10 kg

— injectable containing 67% methyl bromide + 31.8% chloropicrin 2.5-3.65 kg per 100 sq meters (250-365 kg per ha)

— DO NOT USE PRIOR TO A GREENHOUSE LETTUCE CROP

CAUTION — Methyl bromide is a liquid which forms a poisonous gas when released from its container. The chemical is so poisonous to man and livestock that it must be applied with extreme caution and only by applicators who are specially licensed to use this type of fumigant. It must be used under a gas-proof cover, usually plastic. The licensed applicator must make the property owner and all assistants aware of all the precautions that must be taken when using this material. Before using, read the label carefully, wear the correct protective equipment (page 34) and read the section in the Pesticides Act, Ontario Regulation 751, which deals with Methyl bromide soil fumigation. Also see licencing requirements for Methyl bromide (page 40).

(2) Control of Fungi, Bacteria and certain stages of Insects
Formaldehyde (1 L of 37% formalin in 30 L water) 1200 L

(3) Control of Nematodes
DD 2.5 L
Telone 2.5 L OR Telone II 2.0 L
Vorlex 2.5 L

Pre-Crop Fertilizers

A soil test should be made before deciding on any pre-crop application of fertilizer.

The fertilizer schedule shown on page 13 will give full production of tomatoes or cucumbers on any soil that has low fertility. If a grower wishes to increase this fertility level before planting, he may apply superphosphate or 0-20-20 at rates up to 12.5 kg/100 m^2, but the schedule must be adjusted accordingly.

For tomatoes, a pre-crop application of calcium and magnesium may be required because the increasing amounts of potassium applied during the growing season sometimes prevent the absorption of enough calcium and magnesium at that time. The amounts recommended are 3 kg of magnesium sulfate/100 m^2 and 25 kg of calcitic limestone/100 m^2. If calcitic lime is being added for the additional purpose of raising the pH of the soil, consult the lime requirement table (Table 2), using the pH shown in the soil test. In soils where the calcium level is low but the pH is satisfactory, calcium sulphate (gypsum) may be used instead of calcitic limestone. Most vegetables grow best on mineral (sandy) soils at pH 6.0-6.8 and in muck soils at pH 5.5-6.5.

Amounts of material are per 100 square metres unless otherwise stated.

Table 2. Amount of calcitic limestone required to raise soil pH to 7.0 [Neutral]

pH	Sandy loam	Loam	Clay loam	Organic
		kg/100 m		
4.0				500
4.5				450
5.0				350
				300
5.6	62.5	100	250	
6.0	50	75	200	250
6.4	30	50	150	175
6.8	10	20	50	75

Note: In soils with low magnesium content, use dolomitic limestone instead of calcitic. In very alkaline soils with a pH of 7.5 or higher, it may be necessary to lower the pH. Consult your extension horticulturist about materials and rates.

Soilless Culture

Tomatoes and cucumbers can be successfully grown by soilless culture in inert media such as peat, peat + vermiculite, peat + perlite, sawdust, bark chips, sand, etc. Soilless culture requires a more detailed pre-crop preparation than soil culture. Good results are obtained by adding limited amounts of fertilizer. The following table shows the formula for one mix which can be used for satisfactory crop production. Such a mix can be used more than once and can be steamed to eliminate disease if necessary.

Table 3. Peat-Vermiculite mix

	1 cubic metre	(1 cu yd)
peat (sphagnum)	0.5 m^3	(13½ cu ft)
horticultural vermiculite	0.5 m^3	(13½ cu ft)
limestone (Pulverized FF)	5.9 kg	(10 lb)
superphosphate 20%	1.2 kg	(2 lb)
potassium nitrate (KNO_3)	0.9 kg	(1½ lb)
magnesium sulfate ($MgSO_4$)	0.3 kg	(½ lb)
chelated iron (Fe)	37 g	(1 oz)
borax (sodium borate)	37 g	(1 oz)
fritted trace elements	110 g	(3 oz)

Soil Mixes for Seedlings

Many different composts and mixes have been tested and proposed for the growing of vegetable seedling transplants. Artificial culture has proven to be one of the most successful methods of raising healthy, uniform seedlings.

Following are two mixes which give good results:

Soil Mix 1 cubic metre (1 cu yd)	Soilless Mix 1 cubic metre (1 cu yd)
0.6 m^3 loam (16 cu ft)	0.55 m^3 peat (15 cu ft)
0.25 m^3 peat (7 cu ft)	0.45 m^3 vermiculite (12 cu ft)
0.15 m^3 sand (4 cu ft)	1.2 kg calcitic limestone (2 lb)
0.6 kg 20% superphosphate (1 lb)	1.2 kg dolomitic limestone (2 lb)
If pH is below 6.0, add 1.2 kg (2 lb) calcitic limestone.	0.6 kg 20% superphosphate (1 lb)
	0.3 kg potassium nitrate (½ lb)
	0.6 kg 20-20-20 with trace elements (1 lb)
	18.5 g borax (1 tbsp)

Note: 1 m^3 = 1046 L
(1 cu yd = 22 bu)
Mix very thoroughly

Straw Bale Culture

The use of straw bales often makes it possible to grow cucumber crops under conditions which might otherwise be very difficult for instance, where the soil is cold or heavy, or is contaminated with disease, or even on a concrete floor. Straw bales provide a disease-free, well-aerated rooting medium and their use reduces the need for soil sterilization to control diseases. Other advantages are that during fermentation of the straw, heat is produced directly under the plant roots and carbon dioxide is released. Both the extra heat and the carbon dioxide enhance plant growth.

Preparation of the bales involves the application of water and fertilizers to ferment the straw. The following schedule has proved successful for cucumbers. The weights of fertilizers are given in grams per 18-kg bale of straw (normal dry weight).

Day of Treatment

	1	2	3	4	5	6	7	8	9	10	11
Ammonium nitrate	heavy watering daily		140 g			70 g				70 g	
Super-phosphate			0		water	0		water		450 g	water in, apply top-cap, and plant
Potassium nitrate			0			0				370 g	

The superphosphate and potassium nitrate may be omitted from the preparation treatment. However, the plants planted on those bales must be fed with readily available phosphate and potash much earlier than if these nutrients had been applied to the bales.

For planting, a small bed, or so-called top-cap, is put on the bales just deep enough to take the ball of roots. This bed may be made of various materials, but the most suitable appears to be of peat, thoroughly soaked and neutralized with about 9 kg of ground limestone per bale of peat. A mixture of equal parts sterilized loam, peat and sand has also proved successful. If the bales are set into a shallow trench about 15-20 cm deep, the soil dug out of the trench may be used as a top-cap, provided it is well structured and free from pests and diseases.

Management of a crop growing on bales is more critical than of one growing in soil. Watering must be done more frequently, feeding must start earlier and must be heavier.

CROP MANAGEMENT

Seed Treatment

(1) *Hot Water Treatment—Tomato*

This treatment is recommended especially where bacterial canker has occurred in previous crops.

Place tomato seed in a loose cheesecloth bag and soak in water at 50°C for 30 minutes. The treatment may be carried out at 54°C for 30 minutes if the seed is planted within a few days. Use an accurate thermometer and stir the water frequently during treatment. Spread seed out to dry immediately after treatment.

(2) *Chemical Treatment—Tomato*

To destroy tomato mosaic virus on seed coat, treat tomato seed a day or two before sowing. Soak seed for 15 minutes in solution of trisodium phosphate 100 g in 1 L of water. Rinse seed thoroughly with warm water. Spread out to dry.

(3) *Seed Protectants*

To protect all greenhouse vegetable seedlings against soil-borne damping-off fungi, treat the seed with protectant fungicide before sowing, e.g. thiram or captan. Follow manufacturer's directions.

Seedling Production and Timing

The greenhouse production of tomatoes and cucumbers in Ontario is commonly managed on an annual two-crop basis: the spring crop, January 15 to July 15, and the fall crop, August 1 to December 15. There are numerous variations of this arrangement for reasons of marketing, fuel costs and disease susceptibility.

Obtain seed and transplants from reliable sources and grow seedlings under very sanitary conditions. Use vigorous transplants showing no sign of

disease. Transplant into a well-prepared, warm soil that has been steamed or fumigated. Be sure that toxic gases from chemicals applied in soil treatment have disappeared. Determine the safety point by setting a few plants in the soil at least three days before planting the house.

Transplanting: Spacing, Temperature

The yield of fruit obtained from a plant of either crop varies in proportion to the amount of space it occupies in a crop as a result of competition for light. A spacing of 0.37 m^2 (4 sq ft) per plant, i.e. 270 plants per 100 m^2 (250 plants per 1,000 sq ft) is commonly used for tomatoes; 0.46 m^2 (5 sq ft) per plant, i.e. 215 plants per 100 m^2 (200 plants per 1,000 sq ft) for seeded cucumbers; and 0.65-0.84 m^2 (7-9 sq ft) per plant, i.e. 154-119 plants per 100 m^2 (143-111 plants per 1,000 sq ft) for seedless cucumbers.

Greenhouse tomatoes may vary as to their optimum temperature requirements. Most cultivars perform well at a day temperature of 21-24°C and night temperatures of 17°C. Newer cultivars such as Onthyb 774 and 775 (page 5) have been developed with energy conservation in mind. These cultivars set and perform well at night temperatures of 14 and 15°C. In all cases, avoid temperatures over 27°C by evaporative cooling, ventilation and shading. Also avoid conditions of cool nights, high humidity and condensation on ripening tomatoes. This causes cracking.

Cucumbers should be grown at 21°C day and night. Avoid temperatures over 27°C by evaporative cooling or ventilation. Some heat should be provided on cool nights especially after hot days to avoid sweating, and water condensation on the cucumbers. These conditions encourage disease, breakdown in transit and shortened shelf life.

Fertilizer Schedules

(1) *Tomatoes and Cucumbers*

Greenhouse tomatoes and cucumbers must have a proper balance of mineral nutrients continuously to produce a full crop of high-quality fruit. Soils differ widely in the amounts of nutrient reserves that they can supply to plants. A highly fertile soil probably has enough of all the nutrients for the production of one good crop, but continued cropping will deplete these amounts. Light sandy soils have very limited reserves. The amounts present in a soil can be determined from a soil test (page 6).

It is therefore necessary to use large amounts of fertilizer for good crop production, especially in light sandy soils. After transplanting, the plants should be fed small amounts of fertilizer continuously throughout the whole growing season. High-analysis soluble fertilizers can be metered into the irrigation water.

A schedule for the weekly application of fertilizers is shown in Table 4. To estimate the fertilizer needs of the crop the growth should be carefully

watched and the tissue and soil tests should be made periodically. No formula can take the place of good judgment. The schedule should be used only as a guide and should be adjusted to suit the fertility level and the progress of the crop in each greenhouse. It can be used for any crop if adapted in the following ways.

1. Spring crop, low fertility soil, most tomato varieties — Follow schedule unchanged.
2. Spring crop, low fertility soil, variety Vendor and similar early setting varieties — Omit weeks 3, 4, proceed immediately to week 5 after week 2.
3. Spring crop, cucumber, any variety, seeded, seedless — Omit weeks 2, 3, 4, proceed immediately to week 5 after week 1.

Table 4. Guide to Weekly Application of Fertilizer

Recommended Fertilizer—kg/100 m^2

Week	10-52-17	20-5-30	KNO_3 potassium nitrate	$Ca(NO_3)_2$ calcium nitrate	NH_4NO_3 ammonium nitrate	$MgSO_4$ magnesium sulfate
1	1					
2	0.5					
3	0.5					
5	1					1
5		1	0.5	0.5		
6		1	0.5			1
7		1	0.5	1		
8		1	0.5			1
9		1	1	1		
10		1	1			
11		1	1	1		1
12		1	1			
13		1	1			
14		1	1		0.5	1
15		1	1	1		
16		1	1		0.5	
17		1	1	1		1
18		1	1		0.5	
19		1	1	1		
20		1	1		0.5	1
21		1	1	1		
22		1	1		0.5	
23		1	1	1		
24		1.5				
25		1.5				

Caution: Choose soluble fertilizer formulations that are as free as possible of chlorides, sulfates and carbonates.

4. Fall crop, tomato	— Omit weeks 2, 3, 4, proceed immediately to week 5 after week 1.
5. High fertility soil	— Apply fertilizer at one-half the recommended rate until mid-season.
6. Soilless culture	— Use 10-52-17 and 20-5-30 with added trace elements.
7. For 10-52-17	— Can substitute 9-45-15 or 10-52-10.
8. For 20-5-30	— Can substitute 20-20-20 and increase potassium nitrate.
9. Cucumber	— Increase ammonium nitrate application if indicated by crop appearance, tissue and soil tests about mid-season.
10. All crops	— The rates shown below are for production systems where the fertilizer is spread over the entire soil surface. When using an application system that directs the fertilizer to the plant root zone only (e.g. drip irrigation) reduce the application rate according to the actual ground area that is receiving the fertilizer.

Calcium, Magnesium and Trace Elements

When calcium is lacking in the tomato plants, blossom-end rot can appear on the fruit. If this occurs in spite of the recommended pre-crop soil treatment and the calcium application suggested in Table 4, apply calcium phosphate to the soil two or three times during the first half of the growing period at 1 kg/100 m and/or use calcium nitrate in the fertilizer schedule wherever possible in lieu of other forms of nitrogen. If soil applications are not totally effective, a spray of calcium chloride solution may be applied to the leaves at 5 kg in 1000 L of water (see also page 27). Avoid droughts and excesses of water supply. Water regularly in moderate amounts.

Magnesium deficiency on tomato or cucumber may cause a characteristic interveinal yellowing of the lower or middle leaves. If this symptom persists and increases in spite of recommended applications of magnesium fertilizers, apply magnesium sulfate as a spray at 5 kg in 1000 L of water.

WARNING: Do not mix or apply in the same solution a fertilizer containing calcium and one containing sulfate or phosphate. This mixture makes a thick suspension that plugs up mechanical watering equipment. (See also page 30.)

Do not apply trace elements to a greenhouse soil as a regular part of the schedule. If you know or suspect that one or more of these elements are lacking, have tissue and soil tests made. Get the advice of a horticultural specialist before applying a remedy.

(2) *Fertilizer—Lettuce*

Lettuce is a poor feeder so a fairly high level of nutrition must be maintained even though the plant is taking up only a part of what is available. If a good level of nutrition already exists, 1.5-2 kg of 20-20-20 (or equivalent) per 100 m^2 should be worked into the soil before planting. Depending on light conditions, an additional 1-1.5 kg of a similar fertilizer can be applied at two- to three-week intervals. If nitrogen is low or if plants appear pale, 2 kg of ammonium nitrate per 100 m^2 should be used. Sometimes it is necessary to "spot treat" with a nitrogen fertilizer where a drip from the roof or a pipe has caused leaching.

(3) *Fertilizer—Radish*

Usually radishes follow a crop that has been well fertilized. If this is the case, only very moderate amounts of additional fertilizer are needed.

On an average soil without manure, an application of 1.5-2 kg of 20-20-20 per 100 m^2 every two weeks should be sufficient.

Extra nitrogen, after the crop is up, should be added only if nitrogen deficiency is indicated by pale foliage. Excess nitrogen results in large leaves and small, poorly developed roots.

Tissue Testing

Tissue or leaf tests can provide valuable information on the nutrient levels of your tomato or cucumber crop. Leaf analyses for greenhouse crops are made at the Department of Land Resource Science, University of Guelph. Samples should be collected and mailed as follows.

Sampling

Collect a representative sample by taking one leaf from each of 8 to 10 plants chosen at random from plants in the test area (usually one sample per greenhouse).

For tomatoes the standard leaf for tissue analysis is the fifth leaf from the growing tip of the main stem. Tomato plants cannot be sampled after the plants have been topped.

For cucumbers, the sample leaf is usually the third visible leaf from the top, and should be about 10 cm in diameter. After topping, select a similar leaf from the highest lateral on the plant.

Cut the leaf off close to the main stem. With tomato, send in the whole sample for analysis. With cucumber, cut off the petiole close to the leaf and discard it. Send only the leaf portion for analysis.

Preparation for Mailing

Wrap the leaves in a paper towel and place the towel in a plastic bag.

Press as much air as possible out of the bag, and tie with a "twistem" or string.

Place the plastic bag in a standard brown envelope. Also include with the sample:

(1) An information sheet, available from your extension horticulturist or from the Ontario Greenhouse Vegetable Growers Marketing Board, Box 417, Leamington N8H 3W5.

(2) Your cheque, payable to the University of Guelph, for: (a) $11 for each standard test for nitrogen, phosphorus, potassium, calcium and magnesium; or (b) $15 if you wish a test for trace elements (copper, manganese, boron and zinc) as well as the above; or (c) $17 if you wish a test for iron in addition.

Mailing and Results

Mail the sample first class to: Department of Land Resource Science, University of Guelph, Guelph, Ontario N1G 2W1.

It is best to collect the sample and mail it on a Wednesday, so that it will arrive in Guelph on Thursday, or, at the latest Friday. The leaves will be dried over the weekend and testing will begin the following Monday. Only one series of samples will be tested per week.

Test results will be mailed directly to your address with a copy to the extension greenhouse vegetable specialist who serves your area. Contact your extension horticulturist if you need help interpreting the test (page 42).

NOTE: For an ideal, continuous picture of nutritional development, it is advisable to sample once a week, or once every two weeks for an approximate picture. For further information, write for Ontario Ministry of Agriculture and Food Factsheet, *Leaf Analysis for Greenhouse Vegetable Crops*, Agdex 290/532.

Carbon Dioxide Enrichment

The growth of greenhouse plants may be stimulated by increasing the concentration of carbon dioxide (CO_2) above the normal atmospheric concentration of 300 ppm which may fall to 150 ppm in a closed greenhouse with a vigorously growing crop. This may be done by controlled release of pure CO_2 gas from a cylinder, or by burning a fuel such as propane, natural gas or kerosene in a special burner which ensures complete combustion. CO_2 should be added only during the daylight hours, preferably from sunrise to one hour before sunset, and when the ventilators are closed. A concentration of 1200-1500 ppm is the best range for most crops. For further information, write for Ontario Ministry of Agriculture and Food Factsheet, *Using Carbon Dioxide in Greenhouses*, Agdex 290/27.

Pollination: Vibrating, Bees

Tomatoes—Greenhouse tomatoes must be hand pollinated to assure a good set of fruit. This involves tapping or vibrating each flower cluster to

transfer the pollen grains from the anther to the stigma. This should be done regularly as long as there are open blossoms on the flower cluster. The pollen is transferred most readily during sunny periods, with the most difficulty during dark, cloudy days. The electric or battery operated hand vibrator is the most widely accepted tool for vibrating tomato flower clusters. Most red fruited varieties (page 5) pollinate more easily than pinks and can often be pollinated satisfactorily by "tapping" the overhead support wires, or by shaking flowers by air stream from a motor driven backpack duster.

Cucumbers—Pollination of European seedless cucumbers causes off-shape fruit and bees must be prevented from entering the greenhouse. To help overcome this, gynoecious cultivars have been developed which bear almost 100% female flowers. Only gynoecious cultivars are now recommended for commercial production (page 4). American-type cucumbers require bees for pollination. One colony of honeybees per house should be provided. It is advisable to shade colonies from the afternoon sun, and to avoid excessively high temperatures and humidities.

Honeybees fly well in glass and polyethylene plastic houses, but fail to work under certain other types of plastic. Under these conditions, crop failures may occur through lack of pollination.

SANITATION

There is no substitute for good sanitation for preventing insect and disease outbreaks in greenhouse crops.

To keep greenhouses clean, remove and destroy all dead plants, unnecessary mulch material, flats, weeds, etc. Burn or bury all plant refuse. Never leave it in piles near the greenhouse area. Do not contaminate streams or water supplies with plant refuse. Weeds growing in and near the greenhouses after the cropping period should be destroyed. Do not attempt to overwinter garden or house plants in the greenhouses. Pests will also be maintained, for an early invasion of vegetable crops. To prevent disease organisms from carrying over on the structure of the greenhouse and on the heating pipes and walks, spray with formaldehyde 30 L of 37% formalin in 1000 L of water. Immediately after spraying, close up the greenhouse for 4 or 5 days, then ventilate. CAUTION: Wear a respirator when spraying with formaldehyde (page 35).

A 5 metre strip of carefully maintained lawn or bare ground around the greenhouse will help decrease trouble from two-spotted mite and other pests. To reduce entry of whitefly, leafhopper and aphids from weeds and other plants near the greenhouse, spray such growth occasionally with a recommended insecticide.

CROP PROTECTION

The recommendations which follow have been reviewed by the Ontario Pesticides Advisory Committee. Before using any chemical, read carefully the

sections on pages 34 to 40 dealing with Pesticide Poisoning, Relative Toxicities of Recommended Pesticides and Reentry to Treated Areas after treating with pesticides. All pesticide products are registered by Agriculture Canada. No pesticide may be used on any crop for which it is not registered. Such use can result in seizure of the crop.

Monitoring Insect Outbreaks

Insects such as the greenhouse whitefly and leaf miners are attracted to certain shades of yellow and will fly towards that color. Thus, insect traps can be made by painting pieces of board with the correct shade of yellow pigment and then covering the paint with a sticky substance. Similar traps are available commercially from several sources. Consult your extension horticulturist. By placing a number of traps within the greenhouse range it is possible to check infestations daily and be aware of early infestations. Control programs can then be commenced while populations are low (pages 25, 31, 32).

The two-spotted mite cannot be trapped in this way, but infestations usually begin in localized areas first. Check cucumber leaves daily and begin control measures as soon as the first infested areas are noted (page 26).

Application Equipment

There are many types of equipment for applying pesticides, from the high volume or dilute sprayer which apply the pesticide with large quantities of water, to low volume applicators which apply the pesticide with small quantities of water.

Unless otherwise stated, the amounts of material in the following recommendations are for 1000 L of water. This is high volume and such sprays are usually applied in greenhouses at 750-1000 L of water per hectare depending on size of plants, density of foliage, etc. When lower volumes of water are used, it is important to adjust the application rate so that the crop receives an amount of pesticide equivalent to that applied under high volume. This requires precise calibration by the spray operator. Whatever type of applicator is used, thorough coverage of stems and both upper and lower leaf surfaces is very important.

Spray thoroughly. Carefully calculate the correct pesticide application rate and apply so that both the upper and lower leaf surfaces are evenly covered.

> If the crop you want to spray or dust is not listed on the label, do not use the pesticide.

Pesticides: Applications and Precautions

Before using any pesticide carefully read the label and follow manufac-

turer's directions. Wear suitable protective clothing and equipment (page 34). Use recommended respirators to prevent inhaling poisonous materials, and do not work in drift of sprays or dusts. Avoid spilling pesticides on skin or clothing. Wear freshly laundered clothes each day. Wash skin thoroughly after working with pesticides. Never work alone when mixing or applying pesticides in an enclosed area such as a greenhouse. Another person should always be present in case of an accident. DO NOT SMOKE WHEN MIXING OR APPLYING PESTICIDES.

Regulations of Health and Welfare Canada have established the amounts of insecticides and fungicides that are permitted to remain on or in food crops at time of harvest. To avoid exceeding such amounts, follow recommendations exactly. **Residues of an unregistered pesticide on a marketed crop, or excessive residues of a registered pesticide may lead to its seizure, and prosecution.** Safe intervals between the last application of a material and harvest are given in days and enclosed in brackets after each material mentioned in the text. Where two or more materials are mixed, the interval from treatment to harvest must be that of the material having the longest interval.

All pesticide chemicals should be treated as poisons and should be stored in a safe place, well away from children, irresponsible persons, pets, livestock, etc (see pesticide storage, page 40).

Under certain conditions pesticides may cause plant injury. Where possible it is best to test pesticides and especially pesticide mixtures, on a few plants first to check the plant safety factor under your own conditions. Read the warnings on the label and consult the manufacturer's information regarding compatability before using combinations that are not mentioned.

Also read:

If accidents occur — page 39
Pesticide poisoning — page 34
Blood Tests for Those Applying Pesticides — page 38
Protective Clothing When Using Pesticides in Greenhouses — page 34
Relative Toxicities of Recommended Pesticides — page 38

NOTE: Over a period of time an insect or disease may become resistant or immune to certain pesticides. Therefore it is advisable to make alternate applications of the recommended pesticides, where possible.

Cucumber Disease Control

For a general description of cucumber diseases, see Agriculture Canada Publication 1684, *Cucumber Diseases.*

Angular Leaf Spot

Occasionally a problem on seeded cucumbers, especially Highmark II cultivar, in the Leamington area. To date not observed elsewhere. At first appearance, spray or dust with Fixed Copper, as per manufacturer's directions. (1 day).

Basal Stem Rot and Root Rot

Before planting sterilize the soil with steam, or use a soil fumigant (see Soil Sterilization, page 8). Transplant into a well prepared, warm soil (temperature 20°C). Apply a ferbam spray and avoid cold water shock as described on page 22 for late damping off.

Black Root Rot

Ensure that soil temperatures are adequate (20°C) before planting. In areas with cold soils, delay applying a straw mulch until the sun has warmed the soil up. Sterilization with steam is the only fully effective control. Affected plants can often be saved by mounding the base of the stems with a clean soil-peat mixture, so that new roots are formed. The mound should cover the area of the first leaf scar on the stem.

Cucumber Mosaic Virus

Many seedless varieties are highly susceptible to cucumber mosaic, especially when it occurs in combination with certain soil-borne fungi (e.g. *Pythium*). It is almost impossible to keep summer and fall plantings free from mosaic, especially in southwestern Ontario.

The virus is spread by aphids and by handling plants. Infected plants usually wilt and die within a few days. Control aphids. See sanitation (page 18).

Burpee hybrid and High Mark II seeded cucumbers are moderately resistant.

Downy Mildew

Occasionally a problem in August-September planted seedless cucumber crops. Reduce humidity and provide good air circulation. Apply a little heat on cool nights to prevent moisture condensation on the leaves. If the disease appears, spray thoroughly with:

Dyrene 50% WP	1.7 kg	(1 day)
Maneb 80% WP	2 kg	(3 days)
Fixed Copper — Use manufacturer's directions.		

Gray Mold (Botrytis)

Often becomes serious in spring (March-May) and in autumn (September-November). Reduce humidity, provide good air circulation and ventilate freely. Provide adequate heat on cool nights. Remove old leaves and suckers carefully, leaving no snags or tears. Take away all prunings and plant debris

Read and follow label directions when applying any pesticide.

from infected crops. Diseased areas on stems may recover if scraped and covered with a fungicide paste of Ferbam 76% WP.

Spray at weekly intervals until the disease is checked with Ferbam 76% WP 1.5 kg (1 day).

Registration is pending for other fungicides effective against gray mold. Consult your extension horticulturist (page 42).

Gummy Stem Blight

Provide adequate heat and do not allow the crop to sweat at night. Avoid overhead irrigation. This disease is readily spread on fingers, tools and by water splash. Strict sanitation must be practised at all times. Fruit which is suspected of having gummy stem blight should not be included in market consignments. At the time of printing (Jan. 83) there is no recommended chemical control. However, registration of an effective fungicide is pending. Consult your extension horticulturist (page 42).

High Salts

Seeded cucumbers growing in soil with high salts levels will lack vigorous growth, have small blossoms and will not respond to fertilizer applications. If you suspect high salts, have soil tested (page 6), leach as directed, and apply fertilizers that do not build up salts levels rapidly, as recommended in Table 4, page 14. Most seedless cucumber varieties have stronger root systems than the seeded types, and can tolerate a little higher level of salts and fertilization. However, excesses should be avoided.

Late Damping Off

Use only vigorous transplants that show no sign of disease. Transplant into a well prepared, warm soil (temperature 20-21°C) that has been steamed or fumigated (page 8). Be sure that toxic gases from fumigants have disappeared. Determine this by setting a few plants in the soil at least 3 days before planting the greenhouse. Immediately after transplanting, spray the base of the plants with Ferbam 76% WP, 1-2 tsp per 4 L of water. Avoid cold water shock to young plants by pre-heating the irrigation water to 21°C.

Leaf Spot (Alternaria, Tricothecium)

At first appearance, spray with Maneb 80% WP, 750 g (5 day).

Amounts of material are for 1000 litres of water unless otherwise stated.

Post Harvest Breakdown

Under certain conditions seedless cucumbers will deteriorate very quickly after harvest. Several diseases may be involved, including gummy stem blight and scab, especially at the stem end after picking. The breakdown is most frequently seen when several unseasonably cool nights alternate with hot, sunny days in late summer months. It also occurs when storage periods are prolonged after picking, especially at improper temperatures and in poorly ventilated areas. There is no one method of preventing this condition, but especially in summer when you have hot sunny days and below normal temperatures at night take care to:

(1) prevent disease outbreaks

(2) avoid water condensation on the cucumbers, i.e. "sweating" by providing a little heat at night.

(3) avoid overloading, which weakens the plants and causes unhealthy cucumbers that lack turgidity

(4) harvest cucumbers with a sharp knife, leaving a 5 mm stem on each fruit

(5) avoid tearing, fruit bruises, cuts and abrasions

(6) maintain the temperature for marketing and storing at 10-15°C and ideally at 12°C. The relative humidity of the storage area should be between 85 and 95%

(7) avoid accumulation of ethylene gas in the storage areas by keeping cucumbers away from apples and other fruits and by adequate ventilation.

Powdery Mildew

Mildew is less likely to be a problem in the winter or spring crop if seeding is delayed until after December 1. Practise good sanitation (page 18). As soon as mildew appears spray with Karathane WD; 375-625 g per 1000 L or 3.75-6.25 g per 10 L (30 days). Do not apply when temperatures exceed 32°C. Do not mix Karathane with other pesticides.

Pseudo Yellow Virus

A disease new to Ontario seedless cucumber crops that is spread by the greenhouse whitefly. Symptoms are chlorotic yellowing between the veins of older leaves and interveinal yellow spotting on intermediate leaves. Upper foliage may remain unaffected during the early stages. Diseased plants become less productive. There is no known method of control except to control

Read and follow label directions when applying pesticides.

whiteflies. Beets, several species of weeds, and lettuce are known to be alternate hosts. Therefore the practice of alternating leaf lettuce crops with seedless cucumbers may not be advisable.

Scab

Most likely to become a problem in single layer plastic houses, especially under conditions of cool nights when water forms on the cucumbers, followed by sunny days. Cucumber scab may contribute to post harvest breakdown (page 23). Maintain night temperatures at or above 18°C. Provide good ventilation and air circulation, especially in plastic houses to reduce humidity.

Wilting

In the absence of disease or nematodes, wilting often occurs during April and May when warm sunny days follow prolonged cloudy periods, especially on seeded cucumber. Most common causes are unfavorable temperatures, high salts and inadequate root systems. Plants usually recover within a few weeks but frequently some of the lower leaves and occasionally a few of the plants die. Mounding the base of affected plants with soil (preferably muck) to cover the first joint promotes new root growth and hastens recovery. Overhead sprinkling with water may help save plants showing severe wilting.

Sudden Wilt of Seedless Cucumber

This disorder is similar to wilting as described above, but differs in that the root system does not show signs of major decay. and the plants are less likely to recover. Total collapse of the entire plant may be very sudden. All factors that may contribute to sudden wilt are not understood, but investigations have shown that a combination of cucumber mosaic virus and the damping-off fungus *Pythium spp.* is frequently involved. All practices that help prevent damping-off and cucumber mosaic virus should be carefully followed (page 21).

Cucumber Insect Control

Aphids

Prevent aphids from entering the greenhouse by screening the vents and eliminating weeds around the outside. Apply one of the following if aphids are noticed on the lower surface of cucumber leaves:

(1) Greenhouse Dibrom 20 mL/100 m^3 on heating pipes (1 day)
CAUTION: Repeated applications, or single applications at above the recommended dosage, may injure seedless cucumber blossoms.

Amounts of material are for 1000 litres of water unless otherwise stated.

(2) Thiodan 50% WP 1 kg or Thiodan 4 EC 1¼-1½ L (1 day)

(3) Parathion smokes (1 day)

(4) Nicotine smokes (1 day)
See sanitation (page 18).

Greenhouse Whitefly

Biological Control—Whiteflies usually become serious pests on cucumbers and tomatoes unless they are carefully controlled. All stages (egg, nymph, pupa and adult) may be found on the undersurface of the leaves. In late summer and fall, whiteflies enter greenhouses from adjacent field crops, flowers or weeds.

The biological control program uses the parasite *Encarsia formosa*, a small wasp which feeds only on whiteflies. The adults feed on whitefly nymphs and lay eggs in older nymphs and pupae. A parasitized whitefly pupa turns black and an adult parasite emerges later on. You may see the small black and yellow parasite adults sitting on the leaves.

Parasites should be introduced before whiteflies become abundant, or after they have been reduced by chemical treatment (allow 4 or 5 days for residues to disappear). Whiteflies will decline in numbers when the parasite completes several generations, and then both whiteflies and parasites will stay at low numbers. Parasites are susceptible to most insecticides, but Maneb applied at the rate for leaf spot or Safer's Insecticidal Soap at 20 mL per Litre of water will give some control of whitefly adults without harming the parasites.

Greenhouse vegetable growers in Ontario may purchase parasites from the Ontario Greenhouse Vegetable Producers' Marketing Board, Box 417, Leamington N8H 3W5.

For chemical control of greenhouse whitefly, use:

(1) Ambush 500 EC 200 mL (1 day). Note: Resistance has developed in some areas.

(2) Greenhouse Dibrom 20 mL/100 m^3 on heating pipes (1 day). Caution: Repeated applications, or single applications above the recommended dosage may injure seedless cucumber blossoms.

(3) Thiodan 50% WP 1 kg or Thiodan 4 EC 1¼-1½ L (1 day). *Note:* Many strains of whitefly are resistant to Thiodan; others may develop resistance after repeated applications.

Read and follow label directions when applying pesticides.

(4) Parathion smokes (1 day). Generally effective only against light infestations and in small greenhouse areas.

The above materials mainly control adults. Repeat applications at 5-day intervals to prevent egg-laying by newly emerged adults.

Root-Knot Nematode

Before planting, steam the soil or use a soil fumigant (page 8) according to label directions.

Thrips

Use controls recommended for greenhouse whitefly.

Two-Spotted Mite

As soon as the first mite injury is seen remove and destroy all infested leaves. Then begin biological and/or chemical control measures on these plants and the surrounding ones.

Biological Control—The biological control program uses the predator *Phytoseiulus persimilis* which feeds on all stages of the two-spotted mite. This predator is also a mite, but it does not feed on plants, and it can be distinguished by its orange color. *Phytoseiulus persimilis* can be obtained from the Ontario Greenhouse Vegetable Producers' Marketing Board, Box 417, Leamington N8H 3W5. The predators, which are slightly larger than the two-spotted mite, should be placed on the mite-infested cucumbers at a rate of 5 per plant. Examine the plants regularly to check that predators are established. They can be moved on a piece of leaf to other newly infested cucumber plants.

Chemical Control—Spray must be applied to cover both upper and lower leaf surfaces. Mites multiply very rapidly at temperatures over 20°C so April, May and June are critical months. Recommended miticides are:

(1) Vendex 50 W, 500 g — 1 kg (5 days) also helpful where biological control is used because Vendex does not harm the predators. Efficiency is increased when a spreader-sticker is added

(2) Kelthane AP 35% — 750 g (3 days)

(3) Tedion smokes — (1 day)

(4) Greenhouse Dibrom 20 mL/100 m^3 on heating pipes (1 day). Caution: Repeated applications, or single treatments at above the recommended dosage may injure seedless cucumber blossoms.

Amounts of material are for 1000 litres of water unless otherwise stated.

All pesticide products are registered by Agriculture Canada. No pesticide may be used on any crop for which it is not registered. Such use can result in seizure of the crop.

Note: Do not rely on one product for a prolonged period. Alternate between the recommended pesticides. See Sanitation (page 18).

Tomato Disease Control

For general descriptions of tomato diseases, see Agriculture Canada Publication 1479: Tomato Diseases.

Bacterial Canker

(1) Hot Water Seed Treatment

Place tomato seed in a loose cheesecloth bag and soak in water at 50°C for 30 minutes. The treatment may be carried out at 54°C for 30 minutes, if the seed is planted within a few days. Use an accurate thermometer and keep seed agitated during treatment. Spread seed out on a clean surface to dry immediately after treatment. Write for Ontario Ministry of Agriculture & Food Factsheet *Vegetable Seed Treatments*, Agdex 253/23.

(2) Follow a rigid schedule of sanitation throughout the growing season.

Steam or fumigate all soils and containers in which seedlings are grown. Steam or fumigate ground beds before transplanting. Before inexperienced workers handle plants at any time, inspect crop carefully for infected plants. Remove them by placing in plastic bags to avoid contaminating healthy plants as you leave the greenhouse. Bury or burn all infected plants that are rogued out. After handling infected plants, wash hands thoroughly with soap and water. Follow other good sanitary practices. Spray with fixed copper (1 day) at 7 day intervals, or with a tank mix of fixed copper (1 kg) and mancozeb (1 kg) (1 day).

Blossom End Rot

A non-parasitic disease that is related to water stress and calcium deficiency. If rapidly growing plants are suddenly exposed to drought, insufficient water enters the plant and blossom end rot frequently occurs. Practise uniform watering, keep calcium levels adequate and avoid high rates of nitrogen application when plants are small. See page 5 on calcium deficiency. See sections on Soil Testing (page 6) and Tissue Testing (page 16) for helpful information on low calcium levels.

Read and follow label directions when applying pesticides.

Blotchy Ripening

Provide adequate space per plant, i.e. 0.33 -0.42 m^2 (3½-4½ sq ft); control virus diseases (page 30) and maintain relatively high potash levels. Keep greenhouse temperature as low as possible in hot weather. Avoid varieties known to be susceptible to blotch.

Corky Root

Thorough steam sterilization or fumigation with Methyl Bromide (page 8) are the only fully effective controls. There are no registered post-planting controls. The disease often occurs in conjunction with Black Dot Root Rot (Colletotrichum s.).

Damping-off

(a) Seedlings

Obtain seed from reliable sources and treat with a protectant fungicide before sowing, e.g. thiram or captan. Follow manufacturer's directions. Plant in sterilized soil. Provide adequate moisture but do not overwater. Maintain good air movement in the seedling area. Ventilate freely, but do not chill. Preheat the irrigation water to 21°C. Keep humidity low. Dust or drench diseased areas with a suitable fungicide such as captan, ferbam or No-Damp.

(b) Late Damping-off (Collar Rot)

Several species of fungi, either alone or in combination, may attack newly transplanted tomato seedlings at ground level. The fungi cause browning and decay of the outer layers of stem tissue, resulting in either total collapse of the plant, or severe retardation of growth. To control, sterilize the plant beds thoroughly, and practise strict sanitation. After transplanting, spray the stems and surrounding soil with Botran 75% (1¾ kg), or Ferbam 76% WP (2 kg). Repeat in 7-10 days. Avoid cold water shock by pre-heating the irrigation water to 21°C.

Early Blight, Late Blight, Septoria Leaf Spot

Spray with one of the following to keep new growth covered:

(1) Captan 50 WP: 1-3 kg (2 days) — also helps control gray mold

(2) Mancozeb WP: 2 kg (1 day)

(3) Maneb 80% WP: 2 kg (3 days)

(4) Zineb 80 WP: 2 kg (1 day)

Amounts of material are for 1000 litres of water unless otherwise stated.

Caution — Tomato plants may be injured by maneb if it is applied before they are hardened off and transplanted into ground beds. Choose an alternative fungicide if plants are young and tender.

Note: For trade names of the fungicides listed above, see page 41.

Fusarium Crown and Root Rot

A severe disease of spring and fall tomato crops that first appeared in 1974. Earliest visible symptoms are wilting on sunny days, especially when the plants are carrying a heavy load. Related symptoms are thinner than usual tops, and chocolate brown internal stem lesions at soil level.

The disease can be reduced by steaming the soil immediately after taking out the spring crop, and either leaving the ground fallow or preferably growing lettuce to be harvested or rotovated in. No further sterilization is necessary before planting the next crop.

Infection is spread very fast from soil with wilted plants and it is very important to raise seedlings in hygienic conditions well away from affected crops and unsterilized soil. Keep the greenhouses and surrounding areas clear of soil piles, trash, etc. that may harbor the disease. Ensure that soil temperature is adequate for planting. Avoid cold water chilling.

In the fruiting crop, soil mounded over layered stems will encourage new root production from the stem, above the diseased area.

A resistant pink fruited cultivar is now available (see CR-6, page 5). Other resistant pink and red cultivars should be available soon. Contact your extension horticulturist for information (page 42).

Fusarium Wilt, Verticillium Wilt, Black Dot Root Rot (*Colletotrichum*)

Before planting, steam soil or apply a soil fumigant (page 8). Consult the list of resistant cultivars (page 4).

Gray Mold (*Botrytis*)

Often becomes serious in spring (March-May) and in the autumn (September-November). Reduce humidity, provide good air circulation, ventilate freely, and apply one of:

(1) Botran 75% WP 1.75 kg (1 day). Spray stem of plant from ground level to a height of 45-60 cm. Repeat weekly or as necessary. Seedlings or newly set transplants may be injured by drenching.

Read and follow label directions when applying pesticides.

(2) Ferbam 76% WP 2 kg (1 day)

(3) Benlate 50% WP 1 kg (1 day). Note: Many strains of *Botrytis* are resistant to Benlate. Alternate with other recommended fungicides.

(4) Exotherm Termil smoke generators.

(5) See Captan recommendation for Early Blight, page 28.

Note: Registration is pending for other effective fungicides. Consult your extension horticulturist.

Leaf Mold

Grow resistant cultivars where possible (page 4). If susceptible varieties are grown, apply heat and provide good air circulation and ventilate. Remove diseased lower leaves if infection is severe.

Magnesium Deficiency

This will cause older leaves to turn pale green or yellow between the veins. At first appearance of this symptom, apply magnesium sulfate (Epsom salts) two or three times to the soil at 1-1½ kg/100 m^2 or to the leaves as a spray 5 kg in 1000 L water. In greenhouses where the problem has occurred on previous crops, magnesium sprays should be applied even before the symptoms occur. High potassium level in the soil may induce magnesium deficiency. See also page 15.

Tomato Mosaic Virus, Streak Virus, Shoestring

(1) Grow cultivars resistant to or tolerant to TMV (tomato mosaic virus) (see page 4).

(2) To destroy tomato mosaic virus on seed coat, treat tomato seed at least a day before sowing. Soak seed for 15 minutes in solution of trisodium phosphate 100 g in 1 L of water. Rinse seed thoroughly with warm water. Spread out to dry.

(3) Rogue out affected seedlings and plants if disease appears early. After handling diseased plants, field tomatoes, potatoes, bedding plants, and after smoking or handling tobacco in any form, wash hands with soap and water because virus may be carried to greenhouse plants from such sources. Disinfect tools and boots and launder clothing.

(4) Infection with both TMV and Potato Virus X (from potatoes) causes streak virus which severely damages tomato plants. Never handle potato tubers, vines, etc and then proceed to work in your tomato crop.

Amounts of material are for 1000 litres of water unless otherwise stated.

(5) Shoestring is caused by cucumber mosaic virus and is easily transmitted to tomato from cucumbers, melons or several species of weeds. Infection is most severe if it occurs when the tomato plants are very young, i.e. seedling and early transplant stage. Do not grow cucumbers close to the tomato crop.

(6) Control aphids.

(7) Observe general instructions about sanitation (page 18).

Tomato Insect Control

Aphids

Aphids mostly start on lower leaves and if noticed soon enough they can be eliminated by removing and destroying the infested leaves. If the aphids are more abundant or widespread apply one of the following according to label directions:

(1) Greenhouse Dibrom 20 mL/100 m^3 on heating pipes (1 day)

(2) Parathion smokes (1 day)

(3) Nicotine smokes or pressure fumigators (1 day)

(4) Thiodan 50% WP 1 kg or Thiodan 4 EC 1¼-1½ L
OR 3% dust 250 g/100 m^2 (1 day)

NOTE: Thiodan is effective against several species of aphids that attack tomatoes, but it does not kill the green peach aphid which may attack tomatoes. If in doubt as to species, consult your extension horticulturist.

Corn Earworm, Corn Borer, Cabbage Loopers

Often invade fall crops and bore into the fruit. At first appearance, spray with Dipel 1¼ kg or Thuricide HPC 2.8 - 5 L (1 day). Prevent entry of adults (moths) by screening doors and ventilators.

Cutworms

Apply a poison bran bait to the soil surface at 1¼ kg/100 m^2. The bait consists of Sevin 50% WP 1 kg stirred into 11 L water, mixed with 12 kg bran.

Greenhouse Whitefly

For biological control, see recommendations for cucumber (page 25).

Read and follow label directions when applying pesticides.

For chemical control, use one of the following:

(1) Ambush 500 EC 200 mL (1 day). NOTE: Resistance developing in some areas.

(2) Greenhouse Dibrom 20 mL/100 m on heating pipes (1 day)
(3) Thiodan 50% WP 1 kg OR Thiodan 4 EC 1¼-1½ L (1 day). NOTE: Many strains of whitefly are resistant to Thiodan; others may develop resistance after repeated applications.
(4) Parathion smokes (1 day). Generally effective only against light infestations and in small greenhouse areas.

The above materials mainly control adults. Repeat application at 5-day intervals to prevent egg laying by newly emerged adults.

Leaf Miner

Leaf miner was a major problem in several greenhouses in the 1982 spring tomato crop. If seedlings for the spring crop are started while the previous fall crop is still in the greenhouses, leaf miners will migrate from one to the other. Therefore **grow seedlings in isolated areas.** Monitor leaf miner populations by using sticky yellow boards to trap adults (see page 19). Control measures must begin when adults first appear. Spray with:

(1) Ambush 500 EC, used as for greenhouse whitefly will also help control leaf miners, or apply

(2) Malathion 25% WP 4 kg (3 days) or Malathion 500 EC 1¾ L (3 days). Repeat at 4-day intervals.

Root-Knot Nematode

Use control as on cucumber (page 26).

Thrips

Seldom troublesome on tomatoes. If required use one of the chemicals listed for greenhouse whitefly.

Two-Spotted Spider Mite

Rarely a pest in Ontario but a few recently introduced cultivars appear to be more susceptible to damage. If required, use control as for cucumber (page 26).

Amounts of material are for 1000 litres of water unless otherwise stated.

Lettuce and Radish Disease Control

Damping off and *Botrytis* in Lettuce

Spray seedlings with ferbam 76% WP 2 kg or apply ferbam dust (1 day). Repeat once or twice later as needed at 10-day intervals. Provide adequate moisture but do not overwater. Maintain good air movement in the greenhouse. Ventilate freely; keep humidity at moderate levels.

Downy Mildew

Occasionally a problem in late summer and fall crops, especially in plastic greenhouses where high humidity occurs. Provide adequate temperature and ventilation to avoid prolonged periods of leaf wetness.

If the disease appears, spray thoroughly with:

Zineb 80% WP - 2 kg (10 days), or
Maneb 80% WP - 2 kg (7 days) or apply
Zineb dust (7 days) as per manufacturer's directions.

Lettuce and Radish Insect Control

Aphids

Nicotine smokes or pressure fumigants (1 day).

Cabbageworms, Loopers and other Caterpillars

Often troublesome in early fall. Spray with Dipel 1¼ kg or Thurcide HPC 2.8-3.5 L (1 day).

All pesticide products are registered by Agriculture Canada. No pesticide may be used on any crop for which it is not registered. Such use can result in seizure of the crop.

Read and follow label directions when applying pesticides.

PRECAUTIONS WITH PESTICIDES

Pesticide Poisoning

If a person suspects poisoning from exposure to a pesticide by swallowing, inhalation or contact with skin or eyes, the label on the pesticide container should be read and the suggested first-aid treatment carried out.

IMMEDIATELY AFTER THE FIRST-AID TREATMENT HAS BEEN GIVEN, WRAP THE PATIENT IN A COAT OR BLANKET AND RUSH HIM TO THE NEAREST HOSPITAL, TAKING THE LABELED PESTICIDE CONTAINER WITH YOU.

First-aid Information

The Occupational Health and Safety Division, Ministry of Labour, 400 University Ave., Toronto M7A 1T2, has physicians available for consultation on first-aid information and advice. They can be contacted:

Between 8:00 a.m. and 5:00 p.m.
Monday to Friday—Telephone (416) 965-3610

During weekends, public holidays and non-office hours, telephone (416) 965-2111 and ask for the "on-call" physician.

PROTECTIVE CLOTHING WHEN USING PESTICIDES IN GREENHOUSES AND OTHER ENCLOSED AREAS

1. When measuring and mixing pesticides, wear neoprene or rubber gloves, rubber boots, a protective apron or coveralls, and protective eyeshields, unless a full face mask is being worn.
2. Disposable gloves, aprons, overalls and hat covers are available at reasonable prices from the major safety supply companies.
3. Wash all clothing after use.
4. When applying extremely toxic or highly toxic pesticides indoors (page 38) a full-face gas mask with correct canister may be used. Keep a fresh canister on hand as they lose their effectiveness after a certain time. However, a

self contained breathing apparatus (e.g. Scott's Air-Pac) is recommended for the application of this group of pesticides.

5. For methyl bromide a self-contained breathing apparatus, e.g. Scott Air-Pac, must be used for greenhouse work (available from Safety Supply Company, Toronto).

6. When handling, mixing and applying moderately toxic pesticides or when encountering light concentration a dual cartridge respirator should be worn. Consult the following chart for proper selection. Never interchange components.

DUAL CHEMICAL CARTRIDGE RESPIRATORS RECOMMENDED FOR PROTECTION FROM PESTICIDES
(LISTED IN NUMERICAL ORDER ACCORDING TO NIOSH APPROVAL NUMBERS)

NIOSH Approval Number	Approval Issued To	Respirator No. and Description	Component Numbers	Available From
TC-23C-54	Willson	122115 (2 sizes) (formerly Agritox 2)	R21 Cartridges R15 Filters	Safety Supply Co., Toronto
TC-23C-74	Norton	7549L 7549M 7549S (3 sizes)	N7500-21 Cartridges N7500-23 Filters N7500-27 Filter Cover	Norton Co., Safety Product Div., Toronto
TC-23C-78	3M	Powered Air Purifier (pesticide) White Cap Helmet Full-face	Cartridges Filters and Hood and Vest Kit	Safety Supply Co., Toronto
TC-23C-106	American Optical	R4058 R5058 R6058 (3 sizes)	R58A Filter/ Cartridges	AO Safety Products Div., of AOCO, Toronto

TC-23C-117	Scott	Scott Respirator 64-OVP Half-face (3 sizes)	642-OV Cartridges 642-F Filters	Safety Supply Co., Toronto
TC-23C-124	Safety House	236-G100-F 104	G100 Cartridges F104 Filters	Safety House of Canada, Toronto
TC-23C-148	MSA	460560 (3 sizes) Full-face	464025 Combination Cartridges	MSA of Canada, Downsview
TC-23C-178	Norton	75BP 49L 75BP 49M (2 sizes)	N-7500-21 Cartridges N-7500-23 Filters back-pack	Norton Co., Safety Product Div., Toronto
TC-23C-190	Norton	7649L 7649M 7649S Silicone Full-face (3 sizes)	N-7500-21 Cartridges N-7500-23 Filters	Norton Co., Safety Product Div., Toronto
TC-23C-202	H.S. Cover (York)	MY 1482 G	100 Cartridges 104 Filters	Levitt-Safety Ltd., Toronto
TC-23C-224	Scott	Scott Respirator 65-OVP Full-face (2 sizes)	642-OV Cartridges 642-F Filters	Safety Supply Co., Toronto
TC-23C-238	American Optical	R7058 Full-face	R58A Filter/ Cartridges	AO Safety Products Div., of AOCO, Toronto
TC-23C-281	American Optical	R4563 R5563 R6563 (3 sizes)	R563A Filter Cartridges	AO Safety Products Div., of AOCO, Toronto

TC-23C-282	American Optical	R7563 Full-face	R563A Filter Cartridges	AO Safety Products Div., of AOCO, Toronto
TC-23C-323	Survivair	2131-00 2231-00 2331-00 (3 sizes)	1001-00 Cartridge 1030-00 Filters	Levitt-Safety Ltd., Toronto

ADDITIONAL PRECAUTIONS

(a) Dusting
Wear a good respirator or a full-face mask when the label calls for it.

(b) Fogging Machines
Wear complete protective clothing. This includes a hat, jacket and pants or coveralls, rubber gloves, and an air-tight full-face mask or self-contained breathing apparatus.

(c) Insecticide Smokes
Wear a full-face mask or self-contained breathing apparatus when lighting the smokes and when aerating the house. Light the smoke farthest from the door and work toward the door. If smokes are placed in more than one path, more than one man should light them.

(d) Soil Drenches
Pesticides used for this purpose are moderately toxic. Use neoprene or rubber gloves, rubber boots, coveralls, respirator, and protective eye equipment.

(e) Spray Applications
When spraying wear waterproof hat, jacket, and trousers worn outside of boots, neoprene or rubber gloves, and an air-tight face-mask or self-contained breathing apparatus.

(f) Granular Materials
Some granular materials are hazardous. Wear a respirator, water-resistant clothing, protective eye shield, neoprene or rubber gloves, rubber boots with trousers outside of boots. Keep all granules off skin. If contamination occurs, wash immediately with soap and water. After completing application, wash entire body. Wash hands well before eating or smoking.

Make sure all children and pets are out of the greenhouses before treatment begins. Do not work alone.

Blood Tests for Applying Pesticides

Organophosphorus and carbamate pesticides are capable of inactivating and depressing the serum and red blood cholinesterase levels. If the activity falls below a critical level, human poisoning can result as exhibited by fatigue, dizziness, nausea, trembling, blurred vision, difficulty in breathing and other symptoms. For those working indoors and applying these groups of pesticides it is strongly recommended that cholinesterase levels be checked throughout the year by your family doctor. To be of value the tests should be commenced prior to using these pesticides and not after applications have commenced since the normal level per individual can vary considerably making it difficult to assess the degree of suppression. In this publication the primary insecticides of concern are Parathion and Dibrom.

Relative Toxicities of Recommended Pesticides

Extremely Toxic

(1) Methyl Bromide (MC-2, MB-C_2 & Terr-O-Gas 67)
(2) Parathion
(3) All smokes — Nicotine, Parathion, Termil
(4) Fogs of all pesticides listed and not listed here.
(5) Vapor (Dibrom)

Moderately Toxic

(1) Captan*
(2) DD
(3) Telone and Telone II
(4) Thiodan
(5) Vorlex

**Current studies indicate that captan requires special handling procedures as outlined on the label. Follow label directions carefully.*

If Accidents Occur

1. If a pesticide has come in contact with the skin or has been spilled on clothing, remove the clothing and wash the skin thoroughly with soap and warm water. If a pesticide has come in contact with the eyes, rinse with plenty of water for 15 minutes. Wash clothing before reuse.
2. If clothing becomes wet with a pesticide when spraying, remove it immediately. When the spray operation is complete, remove contaminated clothes, have a bath or shower and put on freshly laundered clothing. Wear freshly laundered clothes each day.
3. Clean up any pesticide spills immediately. Use dry soil or other absorbent

Do not work alone when applying pesticides.

material to remove excess liquid. If the spill is major, contact the nearest office of the Pesticide Control Service for advice. (See list page 43.)

4. If symptoms of illness occur during or shortly after handling or applying a pesticide, get the patient to hospital immediately. If possible, take a labeled container of the pesticide with you (see Emergency Procedures for Pesticide Poisoning page 34).

5. If a well becomes contaminated follow clean up instructions in Factsheet, *Pesticide Contamination of Farm Water Supplies*, Order No. 80-025, Agdex 607; available from your nearest office of the Ontario Ministry of Agriculture & Food.

Special Instructions

It should be re-emphasized that all pesticides are toxic and must be handled safely. In addition a number of pesticides (insecticides, fungicides and herbicides) have major deficiencies in their toxicological information because many tests were conducted by the Industrial Biotest Laboratory (IBT) and some of these were invalid. Replacement studies are currently being conducted by the respective registrants. Those handling and applying these chemicals must pay special attention to the precautions outlined above.

At the time of publication (Jan. 1983) the pesticides included in the 1983-84 *Greenhouse Vegetables Production Recommendations* requiring additional studies are as follows:

CSA COMMON NAME	TRADE NAME
captan	Captan, Orthocide
endosulfan	Thiodan
metiram	Polyram
naled	Dibrom
nicotine sulfate	Nicotine, Black Leaf 40

Methyl Bromide and Insecticide Smokes

A permit issued by the Ontario Ministry of the Environment is necessary to use Methyl Bromide (MC-2 and MB-C_2) as recommended for soil fumigation (page 8). To apply for a permit contact:

Pesticides Control Section
Ontario Ministry of the Environment
135 St. Clair Avenue West
TORONTO, Ontario M4V 1P5
Telephone: (416) 965-2401

When using Methyl Bromide or insecticide smoke generators, suitable protective clothing must be worn. After treatment, the greenhouse must be barricaded and warning signs posted. In general, smokes are especially useful for small greenhouses of 1000 m^3 or less. Smoke applications are not satisfac-

tory for spot treatment. Operators applying injectable soil fumigants commercially must be specially licenced by the above ministry. See also page 8.

Reentry to Treated Areas

Pesticide poisoning may occur where workers enter greenhouses too soon after pesticides have been applied. Such poisoning can result from handling treated plants or from inhalation of pesticide vapors. Examine the pesticide label for precautionary statements on working in treated areas.

The pesticides listed below are those for which a specific minimum interval must be observed from the time of application to the time of working in the crop.

Dibrom (vaporized)
Nicotine (smoke generators)
Parathion (smoke generators)

Lock the greenhouse after using one of the above chemicals. Post signs on the doors to indicate danger from poison gas. The minimum interval between application and reentry for these products is 12 hours. Before reentering the greenhouse, ventilate thoroughly to ensure complete safety.

Pesticide Storage

1. Keep pesticides out of the reach of children, irresponsible persons, pets, and livestock. Store them in a ventilated room away from the home, food and feed and keep the room locked. Post pesticide storage area notices.
2. Always store pesticides in original containers and keep them tightly closed. Never put pesticides in unmarked containers.

Disposal of Pesticide Containers and Contaminated Material

1. Containers from pesticide packages and any paper or other material used to clean up spills should be buried or burned. Make sure that people and animals are kept away from the smoke and that the smoke is not directed toward buildings, highways, roads, or public outdoor areas.
2. Un-rinsed containers can contain as much as 3% of the original formulation. If this amount of toxic pesticide is discarded with the drum it could be dangerous to other people handling it, or to the environment (for example, your water supply). Failure to rinse is also wasteful — why not use that 3% for the purpose for which it was purchased, i.e. to control the pest!

   Rinse all empty metal or glass containers three times with water and add washings to the spray tank. Or, use a rinsing device. These rinsers can be used to puncture the bottom of a metal or plastic drum, and to rinse the residual left in the container directly into the spray tank. This procedure takes less than a minute and results in a rinsed container. The rinsed con-

tainers should be crushed, buried and covered by at least 50 cm of soil, away from any watercourse or water table.

Rinsers are available from Phillips Farm Supplies, 96 Sanford St., Brighton, Ontario K0K 1H0, telephone: (613) 475-2040.

FUNGICIDES (Common, Brand and Trade Names)

Common Names	Brand and Trade Names
anilazine	Dyrene
benomyl	Benlate
captan	Captan, Orthocide
chlorothalonil	Exotherm Termil, Bravo, Daconil
dazomet	Mylone, Soil Kare, Basamid.
dinocap	Karathane
dicloran	Botran
ferbam	Ferbam
fixed copper	Fixed Copper, Basicop, Tricop, Kocide 101 (copper hydroxide)
formaldehyde (formalin)	Standard F, Tamblyn F
mancozeb	Dithane M-45, Manzate 200
maneb	Dithane M-22, Manzate D
methyl bromide—chloropicron	
cans	Dowfume MC-2, Sanex MB-C_2
injectable	Terr-O-Gas 67
metiram	Polyram
oxine benzoate	No-Damp
thiram	Arasan, Thiram
zineb	Zineb, Thiogreen

INSECTICIDES and MITICIDES (Common, Brand and Trade Names)

Common Names	Brand and Trade Names
Bacillus thuringiensis	Dipel, Thurcide
carbaryl	Sevin
dicofol	Kelthane
endosulfan	Thiodan
fenbutatin oxide	Vendex
malathion	Malathion
naled	Greenhouse Dibrom
nicotine	Nicotine
parathion	Parathion
tetradifon	Tedion

Do not apply any pesticide more often, or nearer to harvest, than is indicated on the label.

EXTENSION HORTICULTURISTS
ONTARIO MINISTRY OF AGRICULTURE AND FOOD

Counties or Area Served	Name	Address	Phone
Eastern Ontario	Stephan Rowe	College of Agricultural Technology Kemptville K0J 1G0	613-258-3411
Prince Edward, Hastings		P.O. Box 470, Picton K0K 2T0	613-476-3224
Northumberland, Peterborough	Dave Ridgway	P.O. Box 340, Trenton K8V 5R5	613-392-3527
Durham, Victoria, Ontario	Bev Ells	234 King St. East, Bowmanville L1C 1P5	416-623-3348
North York (Bradford Marsh Area)	Matt Valk*	Muck Research Station, R.R. 1, Kettleby L0G 1J0	416-775-3783
Simcoe, Dufferin, Grey	Ken Wilson	P.O. Box 69, Clarksburg N0H 1J0	519-599-2042
Halton, Peel, North Wentworth	Joe Uyenaka	17 Wilson Dr., Milton L9T 3J7	416-878-2314
Niagara Peninsula	Bob Wilcox, Ian Smith, Wayne Roberts	Vineland Station L0R 2E0	416-562-4142
Norfolk, Brant	Russ Chard	P.O. Box 587, Simcoe N3Y 4N5	519-426-7120
Oxford, Elgin	Keith Priest	P.O. Box 666, Woodstock N4S 7Z5	519-537-6621
Lambton, Middlesex, Huron	John Gardner	367 Ridout St., London N6A 2P2	519-434-6811
Kent, Essex	Ed Tomecek	College of Agricultural Technology, Ridgetown N0P 2C0	519-674-5456
Essex, Kent	Clem Fisher, Leslie Huffman	Research Station, Harrow N0R 1G0	519-738-2251
Extension Horticulturist (Potatoes)	Sam Squire	P.O. Box 370, Alliston L0M 1A0	705-435-5521
Extension Horticulturist (Flowers)	John Hughes	Hort. Science Dept. 66 of Guelph	519-824-4120
Extension Horticulturist (Flowers & Mushrooms)	Wayne Brown	Vineland Station L0R 2E0	416-562-4142

Extension Horticulturist (Nursery & Ornamentals)	Burke McNeill	17 Wilson Dr., Milton L9T 3J7	416-878-2314
Extension Horticulturist (Marketing)	Bob Cobbledick	Vineland Station L0R 2E0	416-562-4142
Extension Entomologist	A. "Kitch" Hikichi	P.O. Box 587, Simcoe N3Y 4N5	519-426-7120
Extension Pathologist	Craig Hunter	P.O. Box 587, Simcoe N3Y 4N5	519-426-7120

**Horticultural Research Institute of Ontario staff*

PESTICIDES CONTROL FIELD OFFICES

ONTARIO MINISTRY OF THE ENVIRONMENT

County	District	Telephone
Essex, Kent, Lambton	H. E. Collins, P.O. Box 237, 435 Grand Ave. W. Chatham N7M 5K3	519-352-5107
Elgin, Middlesex, Oxford	D. C. Morrow & W. Lampman 985 Adelaide Street South, London N6E 1V3	519-681-3600
Haldimand, Norfolk, Niagara, Hamilton-Wentworth	J. Percy, Ontario Government Building, 119 King Street West, Hamilton, Ont. L8N 3Z9	416-521-7640
Dufferin, Wellington, Waterloo, Brant	R. Miller, P.O. Box 219, 400 Clyde Road, Cambridge (Galt) N1R 5T8	519-623-2080
Bruce, Grey, Huron, Perth	B. T. Lobb, 20 King Street, P.O. Box 688, Ont. Ministry of Agr. & Food Bldg., Clinton N0M 1L0	519-482-3428

Pesticides Control Field Offices (Continued)

Simcoe, Muskoka	W. Cowie, 12 Fairview Road, Barrie L4N 4P3	705-726-1730
Halton, Peel, York, Durham, Toronto	T. O'Neill & D. Trenholm, 150 Ferrand Drive, Suite 700, Don Mills M3C 3C3	416-424-3000 (Ext. 204)
Peterborough, Victoria, Haliburton, Northumberland	A. G. Carpenter, 139 George Street N., Peterborough K9J 3G6	705-743-2972
Frontenac, Hastings, Lennox & Addington, Prince Edwards, Leeds & Grenville	D. A. Raddon, 133 Dalton Street, Box 890, Kingston	613-549-4000
Prescott & Russell, Renfrew, Stormont, Dundas & Glengarry Ottawa-Carleton, Lanark	R. P. Cameron, 2378 Holly Lane, Suite 204, Ottawa K1V 7P1	613-521-3450
Manitoulin, Nipissing, Parry Sound, Sudbury	D. J. Mewett, Northgate Shopping Centre, 1500 Fisher Street, North Bay P1B 2H3	705-476-1001
Cochrane, Timiskaming, Algoma	P. McCubbin, 83 Algonquin Blvd. West, Timmins P4N 2R4	705-264-9474
	Sault Ste. Marie	705-949-4640
Kenora, Rainy River, Thunder Bay	G. R. Gammond, Ontario Government Building Thunder Bay "F" P7E 6E3	807-475-1305
Head Office	Pesticides Control Section, 135 St. Clair Ave. W., 100, Toronto, Ontario	416-965-2401

THE METRIC SYSTEM

Linear Measures (length)

10 millimetres (mm) = 1 centimetre (cm)
100 centimetres (cm) = 1 metre (m)
1000 metres = 1 kilometre (km)

Square Measures (area)

100 m x 100 m = 10,000 m^2 = 1 hectare (ha)
100 ha = 1 square kilometre (km^2)

Cubic Measures (volume)

Dry Measure

1000 cubic millimetres (mm^3) = 1 cubic centimetre (cm^3)
1,000,000 cm^3 = 1 cubic metre (m^3)

Liquid Measure

1000 millilitres (mL) = 1 litre (L)
100 L = 1 hectolitre (hL)

Weight Measures

1000 milligrams (mg) = 1 gram (g)
1000 g = 1 kilogram (kg)
1000 kg = 1 tonne (t)
1 mg/kg = 1 part per million (ppm)

Weight — Volume Equivalents

(1.00 kg) 1000 grams = 1 litre (1.00 L)
(0.50 kg) 500 g = 500 mL (0.50 L)
(0.10 kg) 100 g = 100 mL (0.10 L)
(0.01 kg) 10 g = 10 mL (0.01 L)
(0.001 kg) 1 g = 1 mL (0.001 L)

Dry — Liquid Equivalents

1 cm^3 = 1 mL
1 m^3 = 1000 L

CONVERSION TABLES — METRIC TO IMPERIAL
(approximate)

Length

1 millimetre (mm)	= 0.04 inch
1 centimetre (cm)	= 0.40 inch
1 metre (m)	= 39.40 inches
1 metre (m)	= 3.28 feet
1 metre (m)	= 1.09 yards
1 kilometre	= 0.62 mile

Volume (liquid)

1 millilitre (mL)	= 0.035 fluid ounce
1 litre (L)	= 1.76 pints
1 litre (L)	= 0.88 quart
1 litre (L)	= 0.22 gallon (Imperial)
1 litre (L)	= 0.26 gallon (U.S.)

Weight

1 gram (g)	= 0.035 ounce
1 kilogram (kg)	= 2.21 pounds
1 tonne (t)	= 1.10 short tons
1 tonne (t)	= 2205 pounds

Pressure

1 kilopascal (kPa) = 0.15 pounds/square inch

Proportion

1 litre per hectare = 14.24 fluid ounces per acre
1 kilogram per hectare = 14.50 ounces per acre
1 kilogram per square centimetre = 14.23 pounds per square inch
1 hectolitre per hectare = 1.10 bushels per acre

Area

1 square centimetre (cm^2)	= 0.16 square inch
1 square metre (m^2)	= 10.77 square feet
1 square metre (m^2)	= 1.20 square yards
1 square kilometre (km^2)	= 0.39 square mile
1 hectare (ha)	= 107,636 square feet
1 hectare (ha)	= 2.5 acres

Volume (dry)

1 cubic centimetre (cm^3)	= 0.06 cubic inch
1 cubic metre (m^3)	= 1.31 cubic yards
1 cubic metre (m^3)	= 35.31 cubic feet
1000 cubic metres (m^3)	= 0.81 acre-foot
hectolitre (hL)	= 2.8 bushels

Speed

1 metre per second	= 3.28 feet per second
1 metre per second	= 2.24 miles per hour
1 kilometre per hour	= 0.62 mile per hour

Temperature

°F = (°C x 9/5) + 32
°C = (°F -32) x 5/9

Application Rate Conversions (Metric to Imperial — Approximate)

litres per hectare x 0.09	=	gallons per acre
litres per hectare x 0.36	=	quarts per acre
litres per hectare x 0.71	=	pints per acre
millilitres per hectare x 0.015	=	fluid ounces per acre
grams per hectare x 0.015	=	ounces per acre
kilograms per hectare x 0.89	=	pounds per acre
tonnes per hectare x 0.45	=	tons per acre

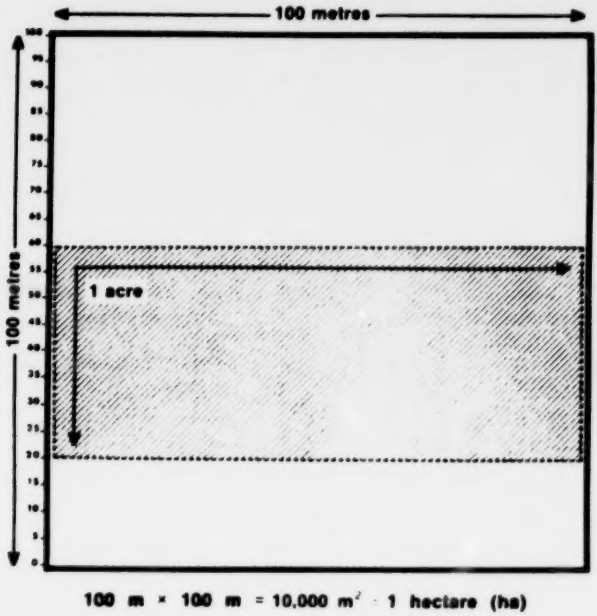
Dry Weight Equivalent

Grams, Kilograms/Hectare		Approximate Ounces, Pounds/Acre
100 grams	=	1-1/2 ounces
200 grams	=	3 ounces
300 grams	=	4-1/4 ounces
500 grams	=	7 ounces
700 grams	=	10 ounces
1.10 kilograms	=	1 pound
1.50 kilograms	=	1-1/4 pounds
2.00 kilograms	=	1-3/4 pounds
2.50 kilograms	=	2-1/4 pounds
3.25 kilograms	=	3 pounds
4.00 kilograms	=	3-1/2 pounds
5.00 kilograms	=	4-1/2 pounds
6.00 kilograms	=	5-1/4 pounds
7.50 kilograms	=	6-3/4 pounds
9.00 kilograms	=	8 pounds
11.00 kilograms	=	10 pounds
13.00 kilograms	=	11-1/2 pounds
15.00 kilograms	=	13-1/2 pounds

Liquid Equivalent

Litres/Hectare		Approximate Gallons/Acre
50	=	5
100	=	10
150	=	15
200	=	20
250	=	25
300	=	30

HECTARE - ACRE PERSPECTIVE



1 hectare	= 2.5 acres
2 hectares	= 5.0 acres
3 hectares	= 7.4 acres
4 hectares	= 10.0 acres
5 hectares	= 12.4 acres
6 hectares	= 15.0 acres
7 hectares	= 17.3 acres
8 hectares	= 20.0 acres
9 hectares	= 22.2 acres
10 hectares	= 25.0 acres
20 hectares	= 50.0 acres
30 hectares	= 74.0 acres
40 hectares	= 100.0 acres
50 hectares	= 123.5 acres

1 acre	= 0.4 hectares
2 acres	= 0.8 hectares
3 acres	= 1.2 hectares
4 acres	= 1.6 hectares
5 acres	= 2.0 hectares
6 acres	= 2.4 hectares
7 acres	= 2.8 hectares
8 acres	= 3.2 hectares
9 acres	= 3.6 hectares
10 acres	= 4.0 hectares
20 acres	= 8.0 hectares
30 acres	= 12 hectares
40 acres	= 16 hectares
50 acres	= 20 hectares
60 acres	= 24 hectares
70 acres	= 28 hectares
80 acres	= 32 hectares
90 acres	= 36 hectares
100 acres	= 40 hectares

METRIC APPLICATION RATES WITH AN ACRE PERSPECTIVE

Dry Weight	Liquid Volume
10 g/ha = 4 g/acre	10 mL/ha = 4 mL/acre
20 g/ha = 8 g/acre	20 mL/ha = 8 mL/acre
30 g/ha = 12 g/acre	30 mL/ha = 12 mL/acre
40 g/ha = 16 g/acre	40 mL/ha = 16 mL/acre
50 g/ha = 20 g/acre	50 mL/ha = 20 mL/acre
100 g/ha = 40 g/acre	100 mL/ha = 40 mL/acre
500 g/ha = 200 g/acre	500 mL/ha = 200 mL/acre
1000 g/ha = 400 g/acre	1000 mL/ha = 400 mL/acre
1 kg/ha = 400 g/acre (0.4 kg/acre)	1 L/ha = 400 mL/acre (0.4 L/acre)
2 kg/ha = 800 g/acre (0.8 kg/acre)	2 L/ha = 800 mL/acre (0.8 L/acre)
3 kg/ha = 1.2 kg/acre	3 L/ha = 1.2 L/acre
4 kg/ha = 1.6 kg/acre	4 L/ha = 1.6 L/acre
5 kg/ha = 2 kg/acre	5 L/ha = 2 L/acre
10 kg/ha = 4 kg/acre	10 L/ha = 4 L/acre
20 kg/ha = 8 kg/acre	20 L/ha = 8 L/acre
30 kg/ha = 12 kg/acre	30 L/ha = 12 L/acre
40 kg/ha = 16 kg/acre	40 L/ha = 16 L/acre
50 kg/ha = 20 kg/acre	50 L/ha = 20 L/acre
100 kg/ha = 40 kg/acre	100 L/ha = 40 L/acre
500 kg/ha = 200 kg/acre	500 L/ha = 200 L/acre
1000 kg/ha = 400 kg/acre	1000 L/ha = 400 L/acre
1 tonne/ha = 400 kg/acre	

POOR

QUALITY

ORIGINAL